Met Office Space Weather Technical Forecast

Space Weather Technical Forecast

Issued on Saturday, 25 March 2023 at 12:34 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

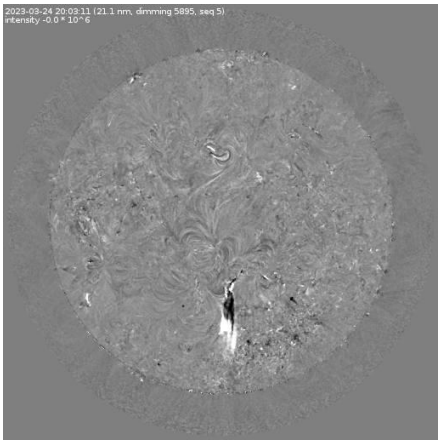
Space Weather Forecast Headline: Now reduced Chance of G1 Minor geomagnetic storms. Ongoing Chance of R1 Minor radio blackouts. Active electron fluence Likely into new week.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with occasional minor C-class flares recorded at GOES16. The largest of these was a C2.2 emitted from the largest and most complex group on the facing side, AR3256 at 24/1340UTC. The above sunspot region is one of eight on the visible disc at present, and is one of relatively few to have shown some growth, with proliferation and increasing penumbral area in its trailing spots for a time. This region was classified as an Fso/Beta-Gamma-Delta, although the penumbra have since fragmented somewhat as the 24-hour period drew to a close to make the Mt Wilson delta spots less distinct. Also of note was AR3260 near north centre disc, which has an east-west aligned magnetic neutral which may increase shear in the group, although this has yet to result in significant activity. To its immediate east, AR3263 showed development of small constituent spots, but only peaked at Cri/Beta complexity. The remaining regions on the disc appear to be mostly stable at present with limited size and magnetic complexity.

No Earth-directed CMEs were observed in available coronagraph imagery. A filament-like emission was observed from the vicinity of AR3256 around 24/1900UTC, however there is no evidence of this having left the immediate solar environment in available imagery. Other peripheral events noted in the period included a prominence eruption from the northwestern limb at 24/2200UTC.

Figure 0: Time-integrated AIA211 imagery of a possible CME-producing event in the period from near Ar3256. Despite appearances, there is not yet any sign of ejecta on coronagraph imagery, and it may well be that this has been re-absorbed to no effect at Earth. Image processing courtesy of SIDC ROB.



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Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 by DSCOVR, showed the extreme tail end of the 23 March CME arrival, soon giving way to a negative polarity fast wind, likely that from CH86/-. The phi angle was initially neutral, but became negative from 24/1800UTC and has remained so since.

Solar wind speeds showed an initial slight decline within Slightly Elevated levels in falling from 450 to nearer 400km/s, however this descent reversed as the fast wind took hold, increasing from 400 to and Elevated level near 525km/s by the period's end. The solar wind density followed a roughly level trend near 10ppcc throughout, while the IMF fell slightly from 11nT in the very last stages of the CME, remaining at or below 10nT thereafter. The north-south component was mainly anti-aligned with Earth's field initially, but became more variable with time, with a range of +6/-7nT observed.

The net result of the above solar wind measures was for initial Active Kp indices falling to Quiet, with a provisional Kp '4+' recorded in the 18-21 and 21-24UTC intervals.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES16 remained at Background levels.

The high energy electron flux (greater than 2MeV) measured at GOES16 has been at mostly Normal Background levels, but with a late increase into Moderate. The associated 24-hour fluence remained below the Active (1e8 integrated pfu) threshold, although now with a slight rising trend. At 25/0001UTC the observed fluence was 1.53e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is most likely to remain Low, but with a Chance of becoming moderate with any isolated M-class flares. The main region likely to give such flares is AR3256 in the south-centre disc.

Solar Wind / Geomagnetic Activity: No Earth-directed CMEs now feature in the forecast.

The only fast wind feature that should form part of the four-day forecast is now in course, with winds from CH86/- most likely to maintain Elevated levels for the current UTC weekend, ahead of a slow decline thereafter.

Geomagnetic activity should peak early in the forecast period with perhaps a Chance of Minor Geomagnetic storm G1, else becoming largely Quiet once again into the new UTC working week as the fast wind wanes.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to remain at Background levels, but with a Slight Chance of reaching S1 or greater, should any significant flares occur.

The high energy (greater than 2 MeV) electron flux is currently showing a degree of recovery with the waning of geomagnetic activity from the 20 March CME(s), and is likely to rise further through the period. The associated 24-hour fluence is expected is also expected to rise, with Active (1e8 integrated pfu) conditions becoming Likely into the new working week UTC.

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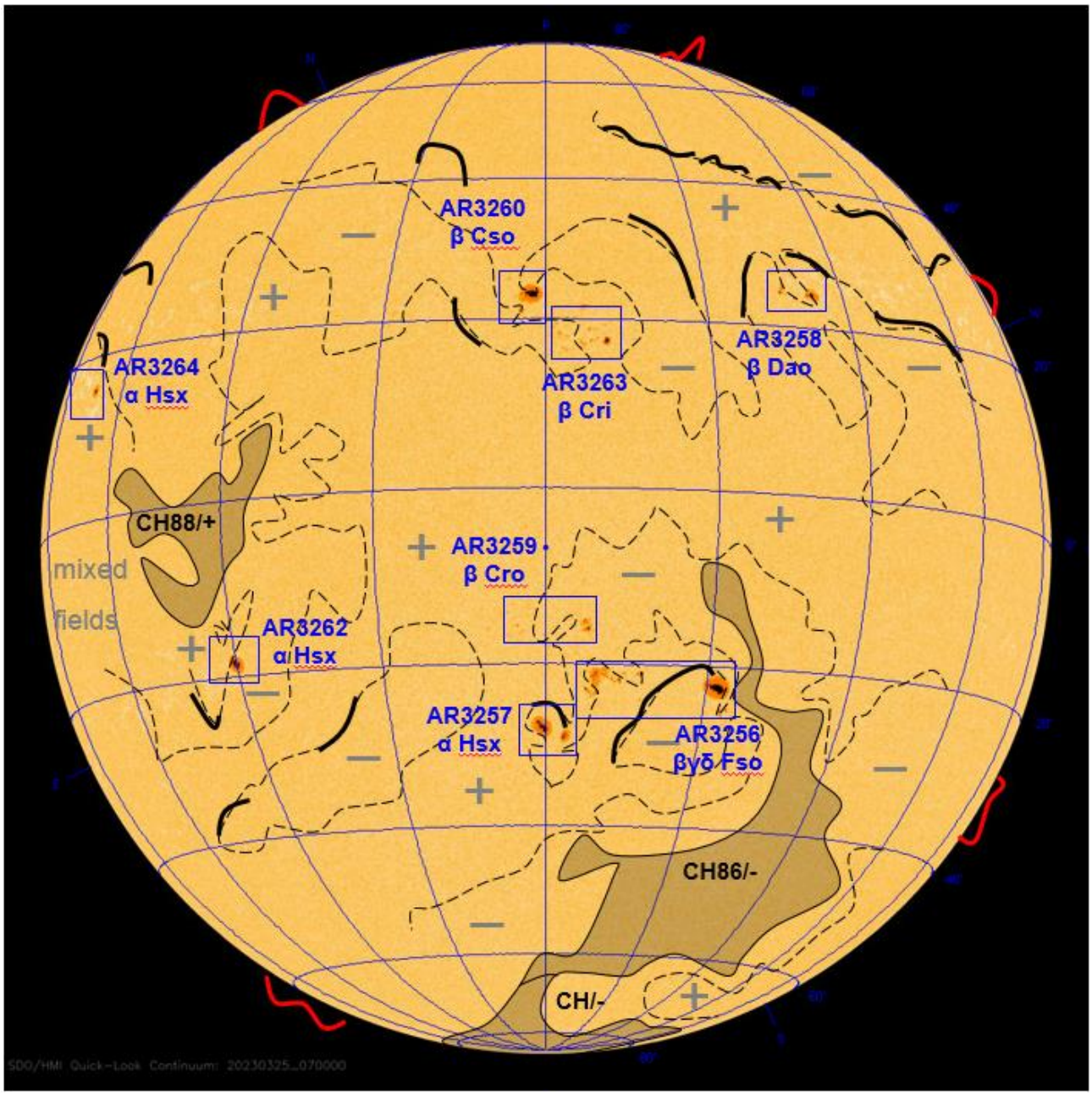
Figure 1. Solar Analysis Valid 25/0700UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No further Earth directed CMEs are currently forecast.

The four-day forecast therefore solely comprises of the fast wind enhancement from CH86/- that is already in course.

Ch86/- is both changed relative to last pass, but also relative to the past few days, with its northern promontory having closed up somewhat, else being largely masked in EUV by flux emanating from AR3256 to its immediate east. Added to this is the fact that STEREO A MAG and PLASTIC measurements to provide a day's forecast upwind are currently very erratic and sparse, and also the fact that the past rotation was heavily polluted by a CME arrival, all add up to a relatively low confidence forecast. In addition, MOSWOC Enlil has only a very tenuous grasp of solar wind conditions at present, with the last vestiges of the 20 March CMEs not followed by any notable fast wind enhancement.

Having said all the above, the coronal hole is showing its character at L1, and the solar wind speed now appears to be plateauing near 550km/s. The solar wind is perhaps likely to remain near this level for the duration of the current UTC weekend before waning as the new UTC working week begins.

The chances of significant geomagnetic activity are now much-reduced relative to the recent past, with activity expected to peak in the next 24 hours before waning in earnest to Quiet conditions into the new working week.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	10	1	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

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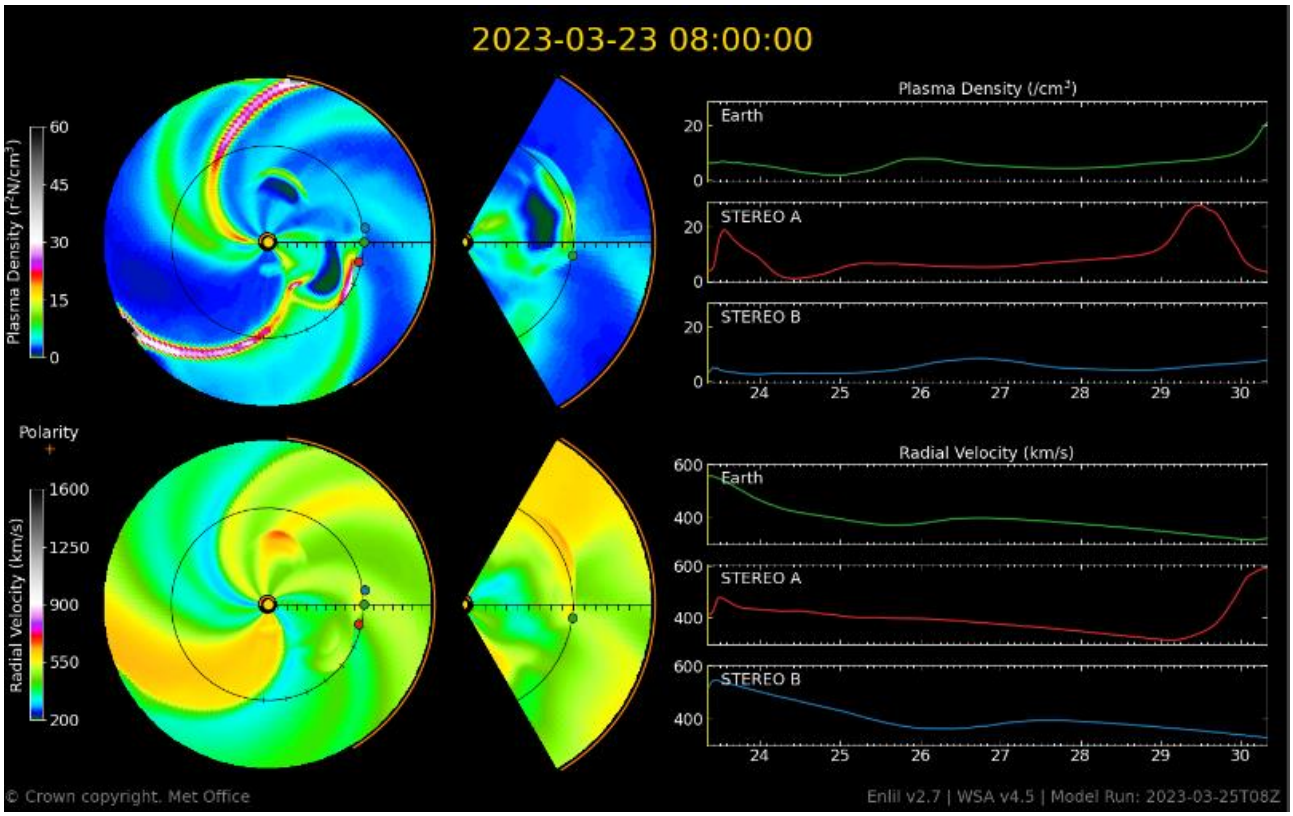
Figure 2: Latest MOSWOC Enlil model run, showing that the current fast wind enhancement from CH86/- is entirely absent. Should any CMEs materialise in the near term, their transit times will need to be adjusted (shortened) by way of compensation. Enlil should become more closely aligned with current observations into the new working week as CH86 wanes.



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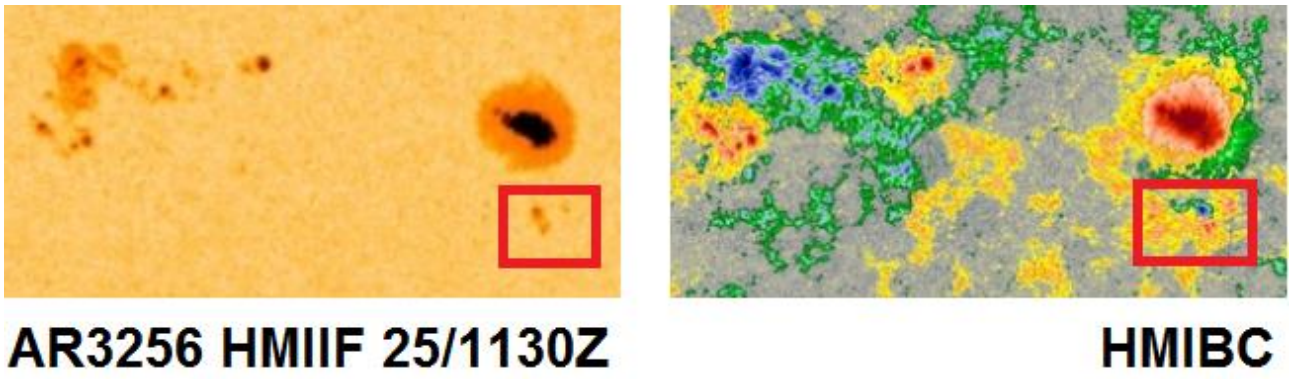
Radio Blackouts - X-Ray Flares:

There are currently eight sunspot regions on the visible disc, and although some of these are nominally large and magnetically complex, with Mt Wilson Delta spots, thus far the effect on X-ray activity has been muted.

Relative to the raw whole-disc probability of near 60% daily chance of M-class flares, a heavy degree of moderation has taken place, with C-class flares currently barely being registered at GOES16. It remains the case that it would not take much development in order for flare activity to increase however, and for this reason a vestigial Chance of M-class is maintained throughout. Regarding the balance of front-side groups, none leave in the four days, while the Carrington locations for up to four regions are due. These do not yet feature in the forecast, with assessment as to any increase in risk they may deliver pending their arrival over the eastern limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	25	25	25
Very Active	R3 to R5 X	No	1	1	1	1

Figure 3: Visible and magnetic imagery of the largest and nominally the most complex sunspot group on the Sun at present. Also shown boxed red is a now tenuous Mt Wilson delta spot. This group has a history of such transitory spots, mainly in its trailers.



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Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES16 is currently at Background levels.

Proton flux is most likely to remain at Background levels, but with a slight chance of reaching S1 or greater should any larger flares occur. The current disc is perhaps under-performing relative to its potential in terms of flares, however the threat remains, and should the sunspot begin to flare appropriately, the risk of S1 events may be adjusted upwards over the four days to account for their westward progress.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux is now showing a degree of recovery in the wake of the 20 March CME(s), with previous Normal Background diurnal oscillations now peaking at Moderate. There is considered a reasonably strong potential for further day-on-day increases in flux, at least over the current UTC weekend now the brakes of strong geomagnetic activity have lifted somewhat.

Active 24-hour integrated electron fluence perhaps carries a Chance of being realised into the new working week UTC, although confidence in this assertion is lowered by the numerous factors impinging on certainty in the 'Geomagnetic Storms' section (and discussed there). For its part, MOSWOC REFM does show a limited increase in fluence levels in its 72-hour forecast, however it remains the case that this is considered underdone given the weak correlation persistence methods are expected to have in light of coronal hole changes and past CME activity.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	30	50	60
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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Figure 4: Top: GOES16 high energy electron flux, showing a recent slight recovery in levels in the wake of strong geomagnetic activity. Also shown is the latest MOSWOC REFM 72-hour forecast and past 24 hours of fluence observations, with the potential for greater rises than shown.

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